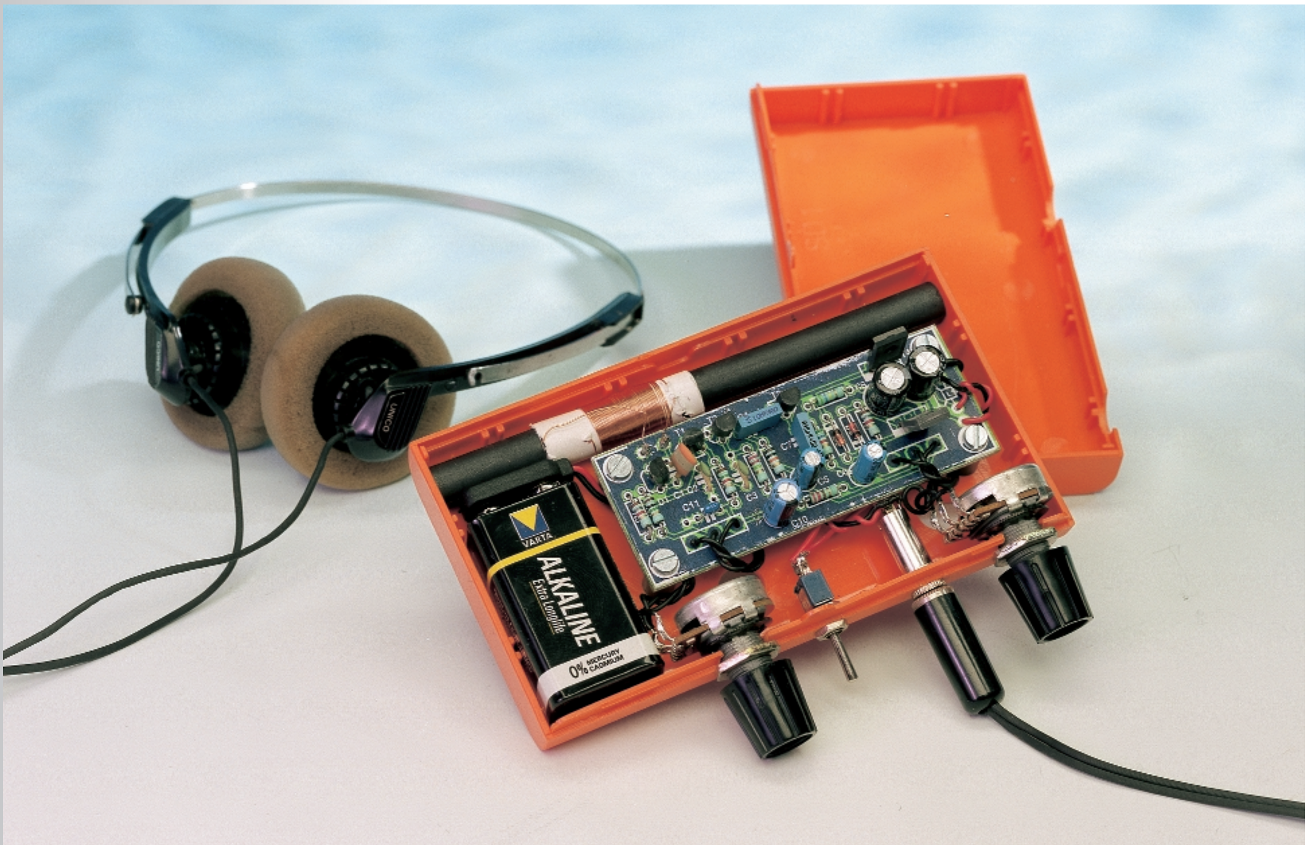
midget medium-wave receiver



The tiny medium-wave (MW) receiver described in this article is an ideal construction project to while away the dreariness of a rainy winter's day. Solder a couple of standard components onto a tiny printed-circuit board, connect the finished board to a battery, and Bob 's your uncle.

Design by G. Baars

Nowadays there are few construction projects or, indeed, commercially available equipment, that use discrete components only. Most apparatus encountered today has at least a processor and/or a number of integrated circuits. Although such equipment has the great advantages of reliability and simplicity, some readers may find the present project in which they can potter about without running into great difficulties a welcome surprise.

The midget radio receiver consists of five common-or-garden transistors, one inductor and a handful of standard passive components. Most readers may well find that they have all the necessary components to hand.

Anticipating the question of some readers whether five transistors are sufficient to build a reasonable receiver, it may already be said that actually only two of these transistors are used in the radio-frequency (RF) stages proper. The other three are needed for the integral mini output amplifier.

Clearly, miracles cannot be expected from two transistors. Nevertheless, it is not the case that a very large antenna is needed to make a tiny signal audible. The midget receiver is perfectly capable of receiving a number of local medium-wave signals without an external antenna. The tuning inductor wound on a ferrite rod picks up these broadcasting stations without external aid.

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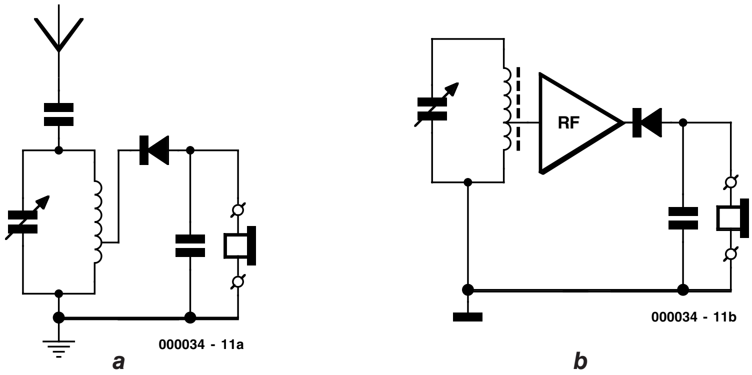

Figure 1. A simple diode receiver (1a) may be improved considerably by the addition of an RF amplifier (1b).

DIRECT CONVERSION RECEIVER

The design is that of a direct conversion receiver. Most constructors will know that there are basically two types of receiver design: the superheterodyne and the direct conversion receiver (also called Tuned Radio Frequency – TRF – receiver).

The superheterodyne receiver, normally called a superhet, is far and away the more popular of the two. It is a design in which a number of tuned circuits are used to increase the selectivity and the received signal is mixed with that of a tuned oscillator. The RF input circuit and the oscillator circuit are tuned in synchrony so as to hold the difference between the frequencies in the two circuits constant. This difference frequency is called the intermediate frequency – IF.

The fact that the output of the mixer, that is, the IF, has a constant value, has the advantage that the stages following the mixer can be filtered without the need for the relevant inductance-capacitance – *LC* – circuits to be tuned for each and every different received signal.

The foregoing makes it clear that a superhet is not a suitable design for a small and simple receiver. However, a direct conversion design is perfectly suitable. In this type of design the received signal is selected, often amplified, and then demodulated. This means that there is no need of an oscillator or conversion to an intermediate frequency.

Figure 1a shows the circuit diagram of a TRF receiver in its simplest form. In this receiver the wanted frequency is selected by a tuned *LC* circuit from the spectrum of frequencies picked up by the antenna. The selected signal is demodulated by the diode and the resulting audio-frequency (AF) signal is fed to a pair of headphones.

A simple receiver as in Figure 1a needs a fairly large antenna. Note that the tuned *LC* circuit is connected between the antenna and earth. So as not to load the circuit too heavily (which would adversely affect the selectivity of the circuit), the detector is normally connected to a tap on the inductor.

The great advantage of the simple receiver is that it does not need a supply voltage. On the other hand, it is not very sensitive and its performance depends largely on the antenna. These drawbacks may be negated to an appreciable extent by the addition of an amplifier. If this is not done, the level of the incoming wanted signal must exceed the forward bias of the diode, that is, the voltage needed to be applied to the diode to make it conduct. In the case of a germanium diode as used here, the forward bias is 100–200 mV.

The addition of an RF amplifier is shown in **Figure 1b**. Such a receiver may have a sensitivity which makes reception with an antenna formed by an inductor wound on a ferrite rod possible.

It must be understood that a direct conversion receiver cannot be compared as regards selectivity and sensitivity with a superhet. After all, the receiver in Figure 1b has only one tuned circuit and one RF amplifier. Nevertheless, it also has some advantages over a superhet. For instance, a TRF receiver is simple to construct,

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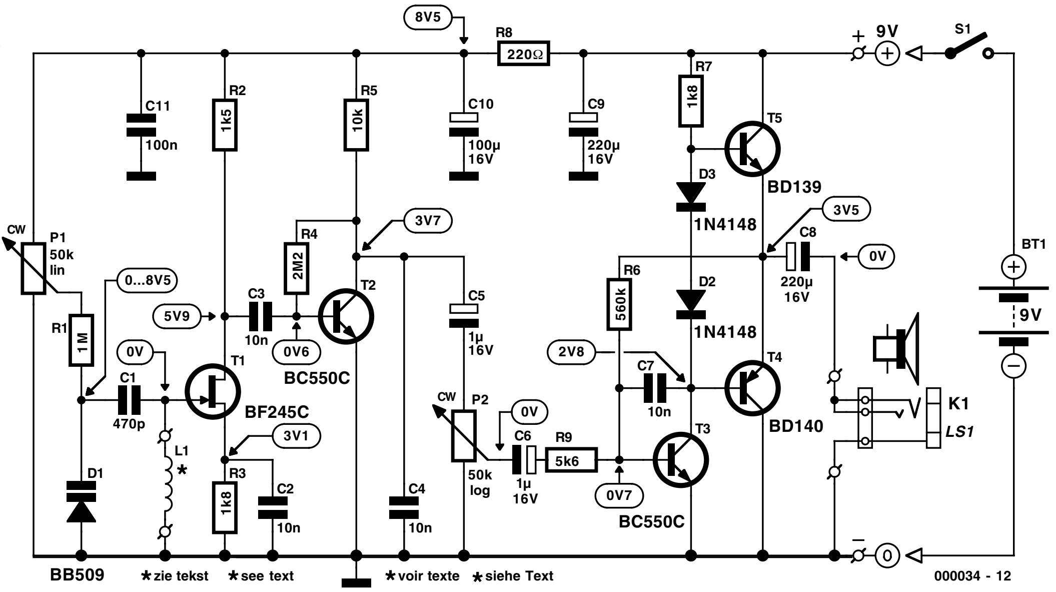

Figure 2. Circuit diagram of the Midget Medium-wave Receiver which is based on only five transistors.

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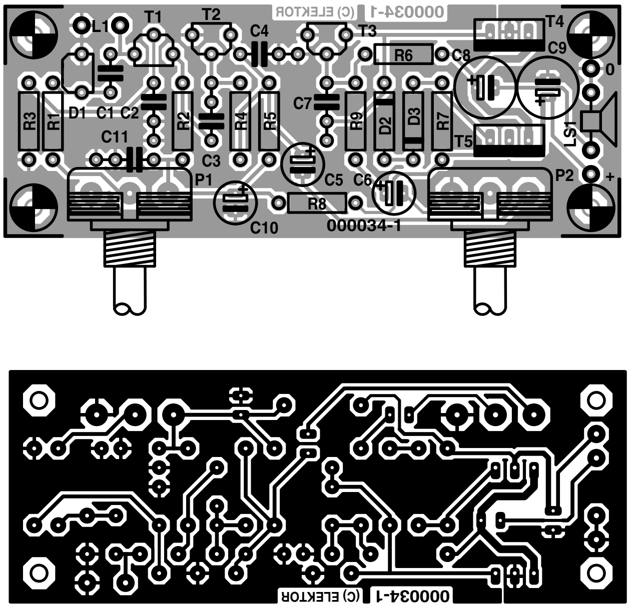

Figure 3. Printed-circuit board for the Midget Medium-wave Receiver.

cheap to make, not critical to set up, does not require much tuning, is free of interfering whistles, and produces good-quality sound.

CIRCUIT DESCRIPTION

The circuit diagram of the midget receiver is shown in **Figure 2**. The receiver proper, that is, the RF section, is to the left of preset P2. Although this is still tiny, it has rather more components than the receivers in Figures 1a and 1b.

The tuned RF circuit consists of inductor L1, capacitor C1, and diode D1. To reduce costs, C1 is not a variable capacitor, but a variable-capacitance (varicap) diode. The capacitance of such a diode varies in accordance with the voltage applied across the diode. That voltage is varied with P1, so that this potentiometer enables the circuit to be tuned as required.

Note that inductor L1 wound on the ferrite rod has no taps unlike those in Figures 1a and 1b. As mentioned earlier, such a tap to which the demodulator or RF amplifier is connected reduces the loading of the inductor and so prevents the *Q*(uality) factor and thereby the selectivity of the circuit being degraded. This is particularly important in the case of a receiver with only one tuned circuit (which determines the overall selectivity of the receiver).

There is, however, a drawback to using a tap and that is that the signal applied to the RF amplifier or demodulator is not the maximum available. In the midget receiver the signal is taken from across the inductor but, since preamplifier T1 is a field-effect transistor – FET – which has a very high input impedance, the inductor is loaded only lightly.

Although T1 provides some gain, the main amplification is provided by

COMPONENTS LIST

Resistors:
R1 = 1MΩ
R2 = 1kΩ5
R3,R7 = 1kΩ8
R4 = 2MΩ2
R5 = 10kΩ
R6 = 560kΩ
R8 = 220Ω
R9 = 5kΩ6
P1 = 50kΩ linear potentiometer
P2 = 50kΩ logarithmic potentiometer

Capacitors:
C1 = 470pF
C2,C3,C4,C7 = 10nF
C5,C6 = 1μF 16V radial
C8,C9 = 220μF 16V radial
C10 = 100μF 63V radial
C11 = 100nF

Inductor:
L1 = 50 turns 0.3mm dia. (SWG30) enamelled copper wire on ferrite rod (10x100mm)

Semiconductors:
D1 = BB509 *
D2,D3 = 1N4148
T1 = BF245C or BF256C
T2,T3 = BC550C
T4 = BD140
T5 = BD139

Miscellaneous:
K1 = 3.5 mm jack socket
S1 = on/off switch
Bt1 = 9-V battery with clip-on connector
Ls1 = earpiece, headphones or 8Ω loudspeaker
Enclosure: e.g., Conrad Electronics 52 09 93 (123x30x70mm)
PCB, order code **000034-1** (see Readers Services page)

*) Available from. Barend Hendriksen Elektronica, P.O. Box 66, NL-6970-AB Brummen, The Netherlands. Tel. (+31) 575 561866, fax (+31) 575 565012. Web site: http://www.xs4all.nl/~barendh/

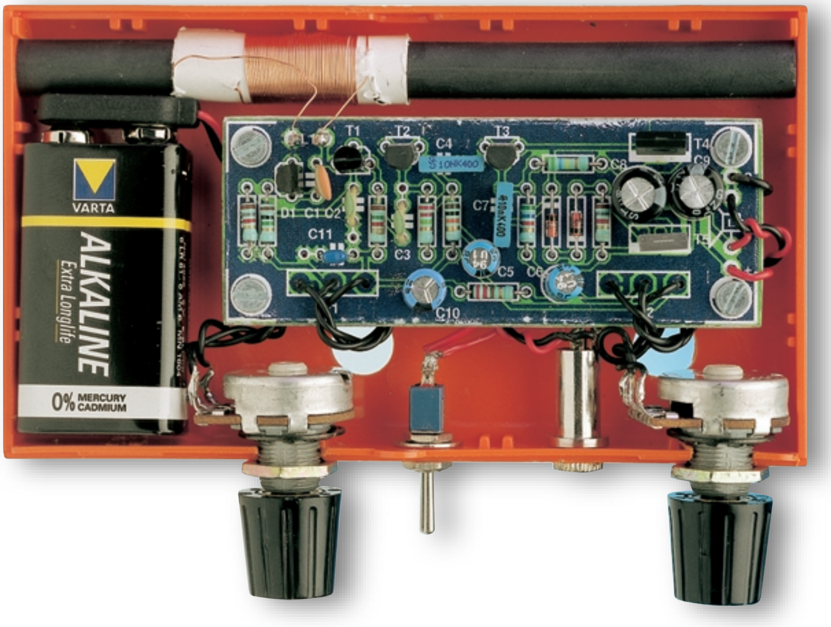

Figure 4. The prototype receiver fits exactly in the chosen enclosure.

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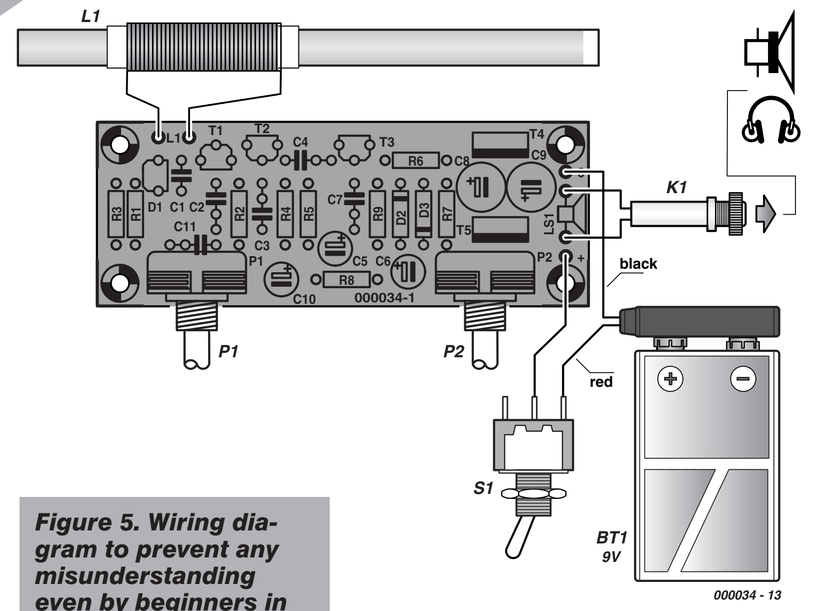

Figure 5. Wiring diagram to prevent any misunderstanding even by beginners in electronics.

transistor T2. This transistor also functions as the demodulator, which is possible since its base-emitter junction is a p-n diode. The residual components of the carrier (signal) frequency are shorted to earth by capacitor C4. The demodulated signal is applied to output amplifier T3–T5 via capacitor C5 and volume control P2

It would have been feasible to use an integrated circuit (IC) for the output amplifier, but discrete transistors were chosen to keep the overall design in line with the RF section. The transistors do not add to the dimensions of the receiver. Transistor T3 functions as a voltage amplifier cum driver, while T4 and T5 form a simple push-pull output stage.

Diodes D2 and D3 compensate for the forward voltage of T4 and T5 so that crossover distortion is an absolute minimum. In quiescent operation, the output stage draws a current of only a few milliamperes.

The output stage is capable of not only driving a pair of headphones (ear pieces in parallel), but also a small 8 Ω loudspeaker. Although the maximum power output is about 1 watt, this is sufficient to fill the average living room with quite enough sound.

POWER SUPPLY

The receiver needs a power supply of 9 V which, since the current drain in normal circumstances does not exceed 30 mA, enables a primary battery to be used. In normal use, the battery will have a fairly long life.

If a mains adaptor is chosen as the power source, it needs to be regulated because the voltage for varicap P1 is derived directly from it.

The absolute level of the supply voltage is not terribly critical. The prototype worked fine with a supply of 7 V, while one of 12 V offers the advantage of improving the sensitivity of the receiver to some extent.

CONSTRUCTION

The midget receiver is best built on the printed-circuit board shown in **Figure 3**. This board is a compromise between small dimensions and a convenient, manageable layout. The latter ensures that populating the board is straightforward.

Start completing the board with the passive components and then the transistors, all the time with constant reference to the illustrations and the parts list. The only item that is not soldered onto the board is inductor L1. This is mounted alongside the board with its two terminals linked to terminations L1 on the board.

Inductor L1 has to be made at home or in the workshop, but this is not difficult. It is wound on a 10–12 cm long ferrite rod with a diameter of 10 mm. Make a cylinder of thin plastic or stiff paper with a diameter that enables it to be just moved to and fro along the ferrite rod. Close-wind 50–55 turns of 0.3 mm diameter enamelled copper wire onto the cylinder. This should be done with great care, because the quality of the inductor will determine the performance of the receiver. The terminals should be fixed in place with sticky tape or by feeding them through tiny holes drilled through the cylinder.

The inductor is the only device in the receiver that needs to be aligned: in this case to the medium-wave broadcast band. Depending on the construction, the self-inductance of the inductor may vary from case to case. This variation may be compensated by sliding the coil across the ferrite rod: when it is at the centre, the self-inductance is a maximum, while at the ends it is reduced somewhat. Measuring instruments are not needed for the alignment. Use another MW receiver as reference and slide the coil until the MW bands on the two are more or less identical. The MW range extends from about 530 kHz to 1605 kHz.

If sliding the coil does not allow the range to be obtained, the number of turns must be adapted. If the range does not extend to 530 kHz, a few turns need to be added; if it does not go up to 1605 kHz, a few turns should be removed. Since removing turns is much simpler than adding some, it is wise by commencing with 55 turns.

ENCLOSURE

When the board has been completed and the receiver works satisfactorily, the board should be fitted in a suitable enclosure. This should be of hard plastic (ABS) or wood, because metal screens the ferrite antenna from the outside world. Ideally, the enclosure should measure 123×30×70 mm and such cases should be available in many model shops or at electronic retailers. The prototype is fitted in one that is of almost exactly the right dimensions (see **Figure 4**). Unfortunately in this, and perhaps also other makes, it proved necessary to fit the potentiometers to the enclosure rather than on the board. If the ferrite antenna cannot be clamped into the case, use two suitable packing blocks at the ends.

Whether a pair of headphones or a small loudspeaker is used is a matter of personal preference. The prototype is used with headphones since the enclosure was just not large enough to house even a tiny loudspeaker. Constructors wishing to use a loudspeaker may find that those commercially available for use with small portable receivers (Walkman) are ideal. These are hardly any more expensive than the constituent parts of a loudspeaker and often give surprisingly good sound reproduction.

CONNECTING UP

Although the various terminations are clearly marked on the board, for convenience's sake **Figure 5** shows exactly how the battery, loudspeaker if used, and ferrite antenna should be linked to the board. This may be of particular help to beginners in electronics.

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